International Journal of Agricultural Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 5, Issue 5, Oct 2015, 393-404

COMPARISON OF DIFFERENT IRRIGATION SYSTEMS FOR GROUNDNUT (*ARACHIS HYPOGAEA L.*)

SHIVASHANKAR. S, MALLESH. S, SAIKIRAN. K, SRAVAN. T, VANDANA. K & RAVI BABU. G

College of Agricultural Engineering, Bapatla, Andhra Pradesh, India

ABSTRACT

The present study was conducted at Field irrigation laboratory, College of Agricultural Engineering, Bapatla, Andhra Pradesh. Groundnut crop was selected for experimental investigations. This study was aimed to optimize the operating pressure and sprinkler to sprinkler spacing for sprinklers and micro sprinklers, and to compare the water requirement, water use efficiency and final yield of groundnut under flood, sprinkler and micro sprinkler irrigation systems. The crop water requirement for the groundnut crop with duration from February 1st week to June 1st week was calculated using CROPWAT as 727.4 mm for Rabi season for Bapatla region. From the investigations it is clearly evident that, the uniformity coefficient for micro sprinkler is higher (85%) at operating pressure of 1 kg/cm^2 and spacing of 2 x 2 m. And for sprinkler the uniformity coefficient is higher (76%) at operating pressure of 1.5 kg/cm^2 and spacing of 8 x 8 m. And the yield of groundnut under micro-sprinkler is high (1.35 t/ha) because the uniformity coefficient and water distribution efficiency of micro sprinkler is high when compared to that of sprinkler and flood irrigation systems. By considering all the factors, we can conclude that the efficiency of micro-sprinkler irrigation system is higher than that of the sprinkler and flood irrigation systems. And the optimum operating pressure, spacing for sprinkler and micro sprinkler is 1 kg/cm^2 at 2 x 2 m spacing, and 1.5 kg/cm^2 at 8 x 8 m spacing respectively.

KEYWORDS: CROPWAT, Groundnut Crop, Uniformity Coefficient, Water Use Efficiency (WUE)

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop, and ranks 13th in importance among world crops. Groundnut is staple food in a number of developing countries. Groundnut is protein rich (26-28%) that grow well in semi-arid regions. It is a good source of edible oil (48-50%) for humans as well as a nutritive feed supplement (as protein cake) for livestock. Like other legumes, groundnut has the additional advantage of adding symbiotically (biologically) fixed nitrogen to the soil. In many parts of the arid climates, virtually every part of the crop is useful (from seed to vine and shell) after harvest. As far as nitrogen is concerned, cropping systems (rotations or mixtures) including a legume is reported to have shown in many cases, very significant benefits for the yields of accompanying mixed cropping.

China is the largest producer of groundnut in the world accounting for more than 40% followed by India with about 15% share. Though, India is the largest cultivator of groundnut crop in terms of acreage, low yields kept in the second place in terms of output. World groundnut production remained at around 35 million tons until mid-2000s and thereafter steadily rose to reach nearly 40 million tons in the 2012. In India, Gujarat is the single largest as well as the best quality groundnut producer accounting for over 40% of total groundnut produced in the country. Groundnut production, within the country, is mainly concentrated in six states including Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka,

Rajasthan and Maharashtra accounting for nearly 90 % of the total production of groundnut in the country. The remaining groundnut cultivated area is scattered in the states of Madhya Pradesh, Uttar Pradesh, Punjab and Orissa.

Groundnut is mainly grown under rain fed situation. Only 19% of groundnut area in India is irrigated. Groundnut crop is exposed to drought conditions very often during its growth and consequently the yields are lower than the potential yield. Hence for increasing the yield of groundnut, system of irrigation is essential. The present research was aimed to optimize the operating pressure and sprinkler to sprinkler spacing for sprinkler and micro sprinklers, and to evaluate the water requirement, water use efficiency and final yield of groundnut under flood, sprinkler and micro sprinkler irrigation systems.

MATERIALS AND METHODS

Selection of Experimental Site

The field required for the experiment was located at the field irrigation laboratory, College of Agricultural Engineering, Bapatla. The field selected for the experiment was completely sandy in nature and the source of irrigation was tube well. Geographically the experimental site is located at latitude of 16^0 N and longitude of 88^0 E with an altitude of 5 m above mean sea level. The experimental site lies in the humid sub-tropical area. The total area of experimental plot 1728 m^2, it was sub divided into 3 plots (for sprinkler, micro sprinkler and flood) of each having 576 m^2.

Land Preparation for Sowing

The field which is selected for the experiment was completely with weeds and stones. The primary tillage operation was carried out by using cultivator, the grass and stones were removed manually. One day after the primary tillage operation the experimental filed was completely spread with Farm Yard Manure (FYM). The FYM was allowed to settle for 10 days, and after that secondary tillage operation was undergone twice with Rotavator. So that a well pulverized, levelled, and fine seed bed was obtained for sowing of groundnut.

Seed Selection, Treatment and Sowing

The groundnut variety of TAG-24 was selected for present experiment. Only bold seeds were used for sowing. The selected kernels were treated with M45 (fungicide), so as to check various seed and soil borne diseases. After that the sowing operation was done by placing the seeds at 30 cm row to row spacing and 10 cm seed to seed spacing by using seed planter

CALCULATION OF CROP WATER REQUIREMENT AND

Irrigation Water Requirement

Water requirement and irrigation schedule for groundnut crop was calculated by using CROPWAT software. CROPWAT is a program that uses the Penman-Monteith equation for calculating reference crop evapotranspiration. These estimates are used in crop water requirements and irrigation scheduling calculations. CROPWAT calculates the irrigation water requirements (either per month or per week period as required) of a cropping pattern in an irrigated area, for various stages of crop development throughout the crops' growing season. The following steps to be follow to operate CROPWAT software.

Data Entry

In order to get the irrigation and crop water requirement, the initial data that are needed for the model was summarized as the follows

- General data
- Crop data
- Soil data
- Reference evapotranspiration data
- Weather data (Effective rainfall, minimum relative humidity, Wind speed data)
- Irrigation option data

General Data

The field which used for conducting experiment was located at College of Agricultural Engineering, Bapatla, India. General geographical data of the field is shown in Table 1.

Table 1: General Data for Calculation of Crop Water Requirement

S.No	Particulars	Value	
1.	Country	India	
2.	Station	Bapatla	
3.	Altitude	5m	
4.	Latitude	16^0	N
5.	Longitude	88^0	E

Meteorological Data

Meteorological data of Bapatla was obtained from the Postharvest technology center Bapatla for the 2011-2013 periods. The following parameters have been collected on a daily basis for 3 years period of (2011-2013)

- Average minimum and maximum air temperature in ° C
- Average minimum and maximum relative humidity in %
- Sun shine hours
- Total precipitation in mm
- Average wind speed in m/s

The above average data was given in CROPWAT software as shown in Figure 1.

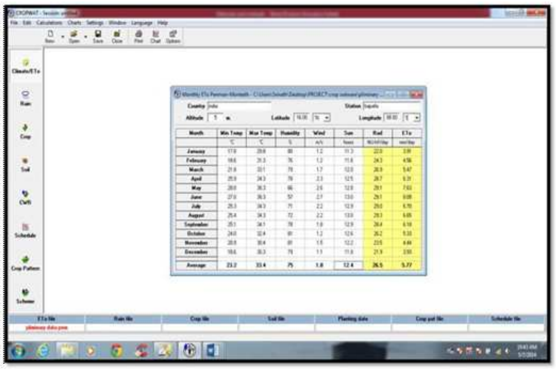


Figure 1: Meteorological Data Entered in CROPWAT

Crop Data

The Kc for different crops are already saved in the software as shown in Table 2. Crop name (Groundnut for present experiment) was selected and enter the planting date then it automatically displays the harvest date and Kc values for different stages and rooting depth for different stages.

Table 2: Crop Coefficients of Some of the Crops

S. No	Name of Crop		Crop Coefficients			
			KC1	**KC2**	**KC3**	**KC4**
1	Paddy		1.10	1.15	1.20	0.90
2	Sugar cane		0.40	1.25	1.25	0.75
3	Tomato		0.45	0.80	1.15	0.65
4	Maize		0.3	0.85	1.2	0.5
5	Groundnut		0.4	0.9	1.1	0.6

Soil Data

After knowing the crop co-efficient at each crop stage then it is required to know the soil parameters. For that we have to select the soil in the CROPWAT software, values for the different soils are already saved in the software for the present experiment the soil is sandy soil so it is to be selected light soils then it gives the information about total available moisture content, maximum rain fall infiltration rate, maximum rooting depth, initial available moisture content as shown in Figure 2. After entering all this data the Kc, ETc and irrigation requirement for the present crop is displayed in decade wise (1decade=10 days)

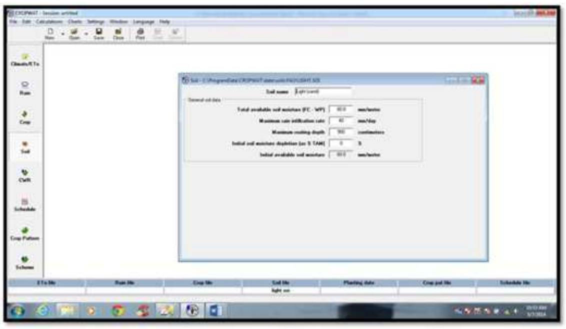


Figure 2: Soil Data Entered in CROPWAT

Irrigation Scheduling

Irrigation scheduling is one of the most important factor. It was calculated by using CROPWAT software.

Experimental Design

Full factorial design was conducted at 2 independent variables (Operating pressure and sprinkler to sprinkler spacing) at 3 levels of operating pressure and 4

Levels of spacing for both sprinkler and micro sprinkler with 2 replications DESIGN EXPERT software was used to calculate the total number of experiments. To optimize the operating pressure and sprinkler to sprinkler spacing for sprinkler and micro sprinklers, ANOVA test was performed to test the significance in variances. To compare the Water requirement, Final yield and Water use efficiency the experiment were conducted with same amount of irrigation water to all 3 plots (flood, sprinkler and micro sprinkler).

Installation of Sprinklers and Micro Sprinklers

Four Sprinklers of each having two nozzle (one is for long distance and another for short distance covering) diameter of 4.5mm and a discharge of 1.55 m^3/h. and twenty four micro sprinklers of each having discharge of 85 l/h are installed in two plots having area of 576m^2 (24 m x 24 m) each.

Optimization of Pressure and Sprinkler to Sprinkler Spacing for Sprinklers and Micro Sprinklers

To optimize the operating pressure and spacing for sprinklers by calculating the uniformity coefficient, the experiments were conducted at 1, 1.5, 2 kg/cm^2 operating pressure and 6 x 6 m, 8 x 8 m, 10 x 10 m, 12 x 12 m. and for micro sprinklers the experiments were conducted at 0.5, 1, 1.5 kg/cm^2 operating pressure and 1 x1 m, 1.5 x 1.5 m, 2 x2 m, 2.5 x 2.5 m spacing. The pressure and sprinkler to sprinkler spacing was optimized based on the uniformity coefficient values.

Calculation of Uniformity Coefficient (Cu)

Distribution of irrigation water throughout the root Uniform zone is an important characteristic of any irrigation system. The sprinklers used for the irrigation of field crops usually cover circular areas. Therefore, an absolutely uniform application is not possible. The degree of sprinkler uniformity is largely depend upon the spacing of the sprinklers, wind velocity, pressure variations, speed and uniformity of rotation, nozzle spacing, and riser height. Uniformity coefficient for sprinkler and micro sprinkler was evaluated by Christiansen method (*Michael, A.M., 1978*) at 1.5 kg/cm^2 operating pressure. The following equation is used to calculate the uniformity coefficient.Coefficient of uniformity

$$(\mathrm{Cu}) = 100(1 - \Sigma X/mn) \quad (1)$$

Where, m = Mean = Sum of all observations/ Number of observations

n= Number of observations

$\Sigma X =$ Numerical deviation of the observations

Post-Harvest Operations of Groundnut

It is necessary to dig the pods at the right time for obtaining higher yields of pods and oil. Nut takes two Months

to attain full development a fully mature pod will be difficult to split easily with finger pressure. This stage is achieved when vine begins to turn yellow and leaves start shedding. Harvesting should be done when good percentage of nuts is fully developed and fairly intact. The matured groundnut crop was harvested manually and threshed to obtain the final yield.

Calculation of Water Use Efficiency

For calculating the water use efficiency, the yield obtained from each experimental site and the amount of water used for each site was recorded. The water use efficiency is the ratio of total yield obtained to that of amount of water used.

Water use efficiency = Total yield / Amount of water applied (2)

RESULTS AND DISCUSIONS

Crop Water Requirement and Irrigation Water Requirement for Groundnut Crop

Crop water requirement (727.4 mm) and irrigation water requirement (634.4 mm) for groundnut during February 1st week to June 2nd week in Bapatla was calculated by entering the crop data, soil data, rainfall and other data in CROPWAT software. The relation between crop water requirement and irrigation water requirement is shown in Figure 3. Initially the crop water requirement and irrigation requirement for first 6 decades was same but after 6th decade the irrigation water requirement was lesser than that of the crop water requirement. Because during the first 6 decades there was no rainfall existed, but after 6th decade some rainfall was existed hence the irrigation requirement was reduced.

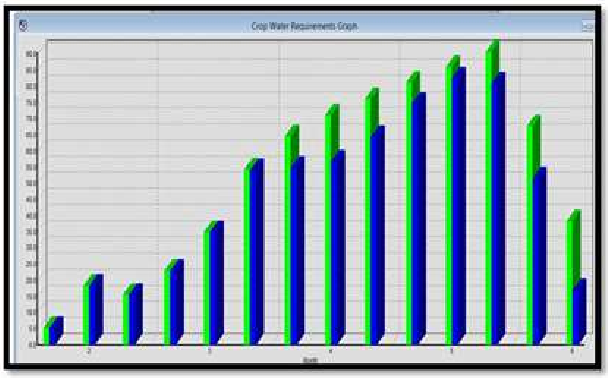


Figure 3: Crop Water Requirement and Irrigation Water Requirement of Groundnut during Crop Duration

Irrigation Scheduling

Irrigation scheduling for groundnut crop during Feb to June was calculated in CROPWAT software and the results were mentioned in Table 3

Table 3: Irrigation Scheduling for Groundnut Crop

Month	Decade	Stage	CWR	Irrigation
			(ETc)	requirement
	(10			
	days)		(Mm/Day)	(Mm/10
				days)
Feb	1	Initial	5.2[a]	5.2 [a]
Feb	2	Initial	18.2 [a]	18.2 [a]
Feb	3	Initial	15.6 [a]	15.6 [a]
March	1	Development	22.9 [a]	22.9 [a]

Table 3: Contd.,				
March	2	Development	35.0 ^{a}	35.0 ^{a}
March	3	Development	54.3 ^{a}	54.1 ^{b}
April	1	Middle	64.5 ^{a}	55.0 ^{b}
April	2	Middle	71.2 ^{a}	56.8 ^{b}
April	3	Middle	76.2 ^{a}	64.5 ^{b}
May	1	Middle	81.2 ^{a}	74.8 ^{b}
May	2	Middle	86.2 ^{a}	82.6 ^{b}
May	3	Middle	90.7 ^{a}	81.1 ^{b}
Jun	1	Late	67.9 ^{a}	51.6 ^{b}
Jun	2	Late	38.3 ^{a}	17.1 ^{b}

Values in the same row with different superscript letters are significantly different

Uniformity Coefficient (Cu)

The uniformity coefficient for sprinkler and micro sprinkler was calculated by "Christiansen method". The uniformity coefficient of sprinkler and micro sprinkler strongly depends on the operating pressure and spacing. The triplicates were conducted for each experiment and uniformity coefficient for sprinkler and micro sprinkler is shown in Table 4 and Table 5 respectively. At lower operating pressure, water will not spread uniformly throughout the field and more amount of water will fall near to the sprinkler. And at higher operating pressure there will be large amount of drift. So that at lower and higher operating pressures the uniformity coefficient will be less. For sprinklers we obtained the higher uniformity coefficient at 1.5 kg/cm^2 operating pressure and 8m x 8m sprinkler to sprinkler spacing as shown in Figure 4 (a, b, c, d, and e). And for micro sprinklers we obtained the higher uniformity coefficient at 1 kg/cm^2 operating pressure and 2m x 2m sprinkler to sprinkler spacing as shown in Figure 5 (a, b, c, d, and e).

Table 4: Uniformity Coefficient for Sprinkler Irrigation

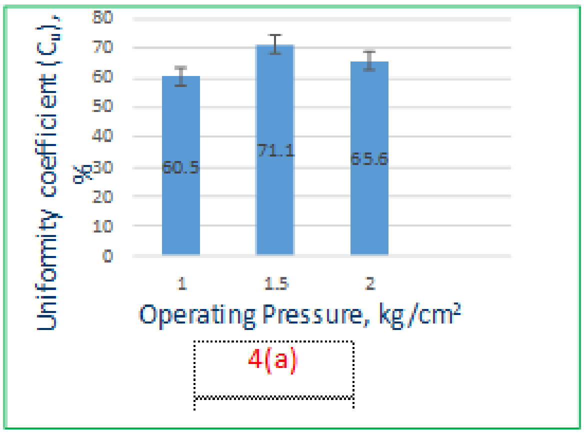
Pressure Kg/cm^2	**1 kg/cm^2**				**1.5 kg/cm^2**				**2 kg/cm^2**			
Sprinkler Spacing	6m x 6m	8m x 8m	10m x 10m	12m x 12m	6m x 6m	8m x 8m	10m x 10m	12m x 12m	6m x 6m	8m x 8m	10m x 10m	12m x 12m
Uniformity coefficient (C_u), %	60.5 ± 0.5	66 ± 1	64.1±1.258	60.5 ± 0.5	71.1±1.258	76 ± 1 ^{A}	75.3±1.527	71.1±1.258	65.6±0.763	69.± 0.5	67.8 ± 1.04	65.6±0.763

Values are presented as Mean ± S. D (N = 3). Value having A as superscript indicates high uniformity coefficient.

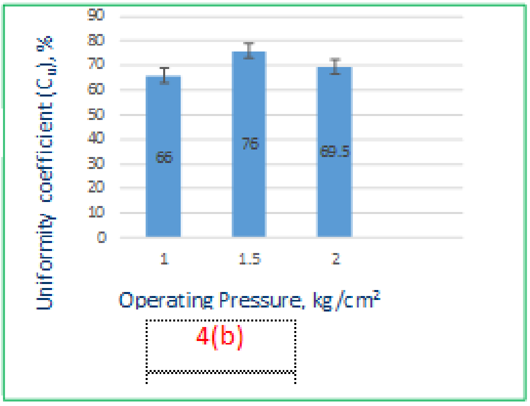
Table 5: Uniformity Coefficient for Micro Sprinkler Irrigation

Pressure Kg/cm^2	**0.5 kg/cm^2**				**1 kg/cm^2**				**1.5 kg/cm^2**			
Sprinkler spacing	1m x 1m	1.5m x 1.5m	2m x 2m	2.5m x 2.5m	1m x 1m	1.5m x 1.5m	2m x 2m	2.5m x 2.5m	1m x 1m	1.5m x 1.5m	2m x 2m	2.5m x 2.5m
Uniformity coefficient (C_u), %	62.16 ±1.258	65.5 ±0.28	67.83 ±0.763	64.16 ±1.258	80.83 ±1.040	82.3 ±0.76	85 ±1 ^{A}	82.16± 2.02	71.83± 0.763	76 ± 1	77.33± 1.25	73.5± 1.322

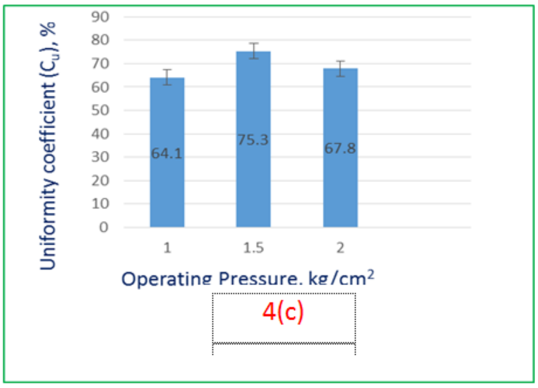
Values are presented as Mean ± S. D (N = 3). Value having A as superscript indicates high uniformity coefficient


Uniformity coefficient (Cu), %
80
70
60
50
40
30
20
10
0
60.5
71.1
65.6
1
1.5
2
Operating Pressure, kg/cm2

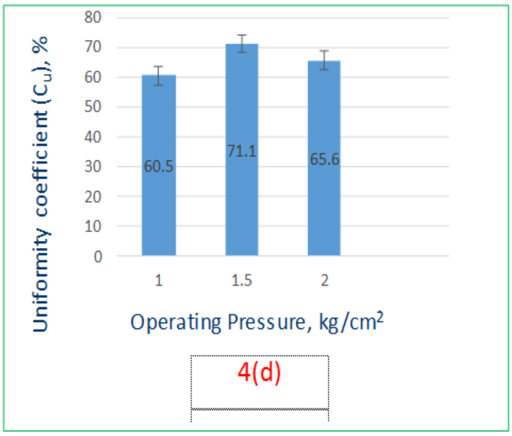
4(a)


Uniformity coefficient (Cu), %
90
80
70
60
50
40
30
20
10
0
66
76
69.5
1
1.5
2
Operating Pressure, kg/cm2

4(b)


Uniformity coefficient (Cu), %
90
80
70
60
50
40
30
20
10
0
64.1
75.3
67.8
1
1.5
2
Operating Pressure, kg/cm2

4(c)


Uniformity coefficient (Cu), %
80
70
60
50
40
30
20
10
0
60.5
71.1
65.6
1
1.5
2
Operating Pressure, kg/cm2

4(d)

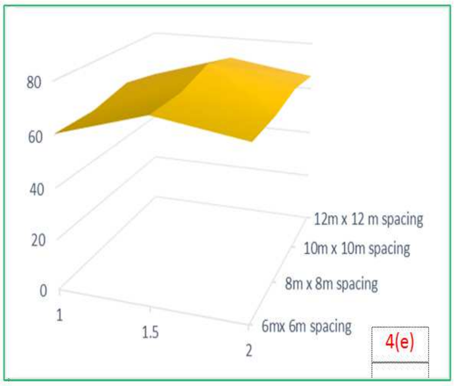
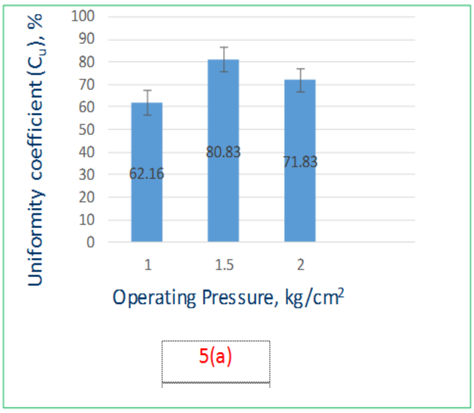
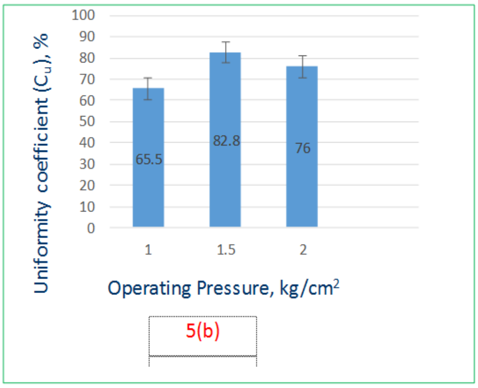
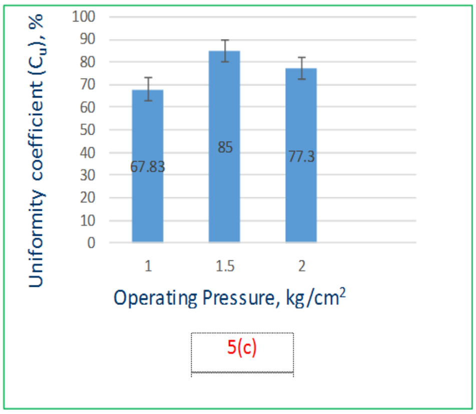
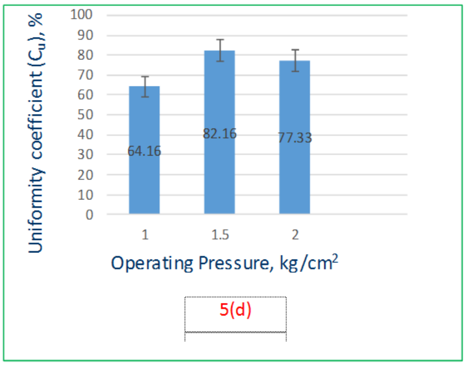


Figure 4: Uniformity Coefficient of Sprinklers at Different Operating Pressures and (a)at 6m X 6m Spacing (b) at 8m X 8m Spacing (c) at 10m X 10m Spacing and (d) at 12m X 12m Spacing.









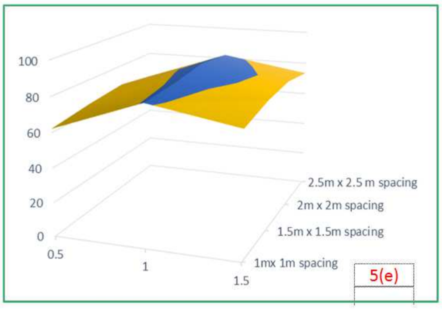


Figure 5: Uniformity Coefficient of Micro Sprinkler at Different Operating Pressures and (a)at 1m X 1m Spacing (b) at 1.5m X 1.5m Spacing (c) at 2m X 2m Spacing and (d) at 2.5m X 2.5m Spacing

Yield of Groundnut

The total yield of groundnut for different experimental plots was calculated and shown in Fig 6. The yield obtained from sprinkler irrigation, micro-sprinkler irrigation is more (20%, 35% for sprinkler and micro sprinkler respectively) as compare to the flood irrigation system (1t/ha). This may be due to the efficient application of water and proper aeration in the root zone which helps for the favorable conditions for growth of the plant.

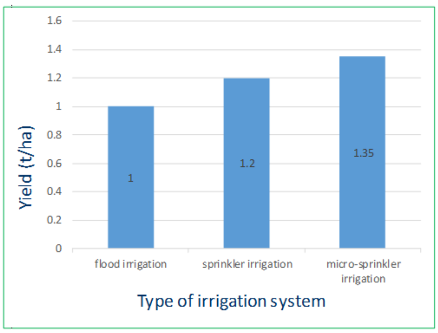


Figure 6: Comparison of Groundnut Yield under Different Irrigation Systems

Water Use Efficiency

Water use efficiency of the different irrigation systems was calculated and shown in Fig 7. The results of water use efficiency stated that the micro-sprinkler irrigation is the best among all other treatments. The micro-irrigation system of groundnut was recorded high water use efficiency as 0.0185 t/ha-cm. and followed by the treatments sprinkler irrigation and flood recorded as 0.0165 and 0.013745 t/ha-cm respectively.

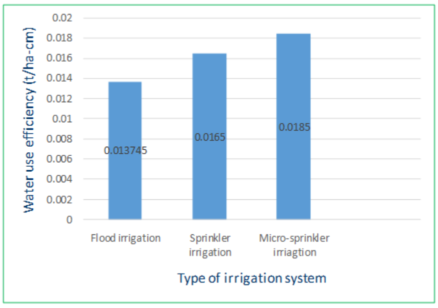


Figure 7: Comparison of Groundnut Yield under Different Irrigation Systems

CONCLUSIONS

The following are the conclusions drawn from the experimental results.

- The crop water requirement for the groundnut crop was calculated using CROPWAT as 727.4 mm for *Rabi* season for Bapatla region.
- The uniformity coefficient for Sprinkler at pressure 1.5 kg/cm^2 and 8m x 8m sprinkler to sprinkler spacing is more as compare to other readings. Hence we can conclude that the optimum operating pressure and for sprinkler to sprinkler spacing is 1.5 kg/cm^2 and 8m x 8m respectively. Because the overlapping at 8 m x 8 m sprinkler spacing is acceptable to the theoretical value.
- The uniformity coefficient for Micro Sprinkler at pressure 1.5 kg/cm^2 and 8m x 8m sprinkler to sprinkler spacing is more as compare to other readings. Hence we can conclude that the optimum operating pressure and for sprinkler to sprinkler spacing is 1kg/cm^2 and 2m x 2m respectively. Because the overlapping at 2 m x 2 m sprinkler spacing is acceptable to the theoretical value.
- The yield obtained from the field of flood, sprinkler and micro-sprinkler irrigation systems are respectively 1t/ha, 1.2 t/ha and 1.35 t/ha. So we can conclude that the yield of micro-sprinkler is high because of optimum frequency of application water.
- The water use efficiency of flood, sprinkler and micro-sprinkler irrigation systems are respectively 0.013745 t/ha-cm, 0.0165 t/ha and 0.0185 t/ha. The water use efficiency in micro-sprinkler is high because of the yield obtained from micro-sprinkler is high.

ACKNOWLEDGEMENTS

The authors express sincere thanks to Acharya N. G. Ranga Agricultural University for giving financial support during the period of research.

REFERENCES

1. Abdelhadi A., Hata W., Tanakamaru T., Tada H. (2000). Estimation of crop water requirements in arid region using Penman-Monteith equation with derived crop coefficients. *Agricultural water management 45, 203-214.*
2. Gomes E.P., Roberto Rezende., Paulo SérgioLourenço de Freitas., Marcos Antôno de Sousa Lacerra. (1997). Irrigation uniformity for micro-sprinkler operating below of the working head in different distances simulations. *Pesquisa Applicada & Agrotecnologia Journal 1, 19-25.*

3. Koumanov K.S., Hopmans J.W., Schwankl L.J., Andreu L., Tuli A. (1997). Application efficiency of micro-sprinkler of almond trees. *Agricultural Water management 34, 247-263.*
4. Michael, A.M. (1978). Irrigation theory and practices, *Vikas publishing house Pvt. Ltd., Delhi, P. 652-661.*
5. Mugisha J., Ogwal R., Ekere W., Ekiyar V. (2004). Adoption of IPM groundnut production technologies in eastern Uganda. *African Crop Science journal 12(4), 383-391.*
6. Thiyagarajan G., Ranghaswami M.V., Rajakumar D., Kumaraperumal R. (2010). Deficit Irrigation on groundnut (Arachis hypogaea L.) with Micro Sprinklers. *Madras Agricultural Journal 97(1-3), 40-42.*

AUTHOR DETAILS

- SHIVASHANKAR S

Shivashankar has completed his B.Tech (Agriculture) degree from College of Agricultural Engineering, Bapatla, and Andhra Pradesh, India.

Now he is doing M. Tech at dept. of “AGRICULTURAL AND FOOD ENGINEERING, IIT KHARAGPUR”